

HOHOKAM IMPACTS ON THE VEGETATION OF CANAL SYSTEM TWO, PHOENIX BASIN

BY DAVID JACOBS AND GLEN E. RICE

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Compiled by
Brenda L. Shears
Glen E. Rice
Peggy Lindauer
Haure Yoshida

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OFFICE OF CULTURAL RESOURCE MANAGEMENT
DEPARTMENT OF ANTHROPOLOGY
ARIZONA STATE UNIVERSITY

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**David Jacobs
Glen E. Rice**

INTRODUCTION

In 1850, the Phoenix Basin had been uninhabited for about 350 to 400 years. It was visited occasionally by hunting, fishing, or gathering parties from the Pima, Pee Posh, Yavapai or Apache, but the last people to have cleared farming fields, excavated canals, and built villages in the lower Salt River valley had been the Hohokam, and they had abandoned the area sometime between A.D. 1450 and 1500.

This timeline is important to archaeologists because it means that the desert vegetation in the lower Salt River valley had had more than three centuries to return towards a natural climax that was only minimally affected by human intervention. (In some places the abandoned canals continued to have a relict affect on vegetation as discussed below.) Archaeological evidence suggests that the composition and approximate distribution of plant communities in 1850 resembled those that had last existed in the basin at around A.D. 300 to 400, when the Hohokam were just beginning to grow in population size.

The vegetation distribution in 1850 provides a useful baseline for researchers who wish to study the impact of the Hohokam on their landscape during nearly 1000 years of irrigation agriculture along the lower Salt River. Indeed, by the end of the 19th century, the establishment of new settlements and the resurgence in irrigation agriculture in the Phoenix Basin had begun to change the vegetation of the basin once again and, by the early 20th century, the large mesquite bosques had been cut down, and the once-thick stands of saguaro cacti on Papago Buttes were greatly diminished.

Fortunately, there is an accurate (although not overly detailed) record of Phoenix Basin vegetation as it appeared in 1867 and 1868; this record is contained in the logs kept by members of the U.S. Public Land Survey teams as they mapped out the boundaries of townships and sections used to record land property ownership (Cable and Mitchell 1988; Kwiatkowski 1994). Those notes are used here to develop a map of vegetation in the area of Canal System Two as it appeared in 1868 and as it might have appeared at the start of the growth of the Hohokam canal system around A.D. 300-400. We then look at the ways in which the Hohokam gradually altered the landscape to suit the requirements of their irrigation systems and communities.

THE METHOD FOR GENERATING THE MAP

Our use of the 1867 and 1868 cadastral survey logs to construct a vegetation map of Canal System Two follows the examples of earlier researchers who used the data to construct maps for parts of the area. Kwiatkowski (1994) used the survey notes to

construct a vegetation map for a 5km radius around the site of Pueblo Grande; in addition to illustrating the basic procedures, he discussed the vegetation terms used in the survey notes (Kwiatkowski 1994:9-11). Cable and Mitchell (1988:429-431) also used the cadastral survey records to map the large mesquite bosque that covered much of the southwestern portion of Canal System Two.

The Public Land Survey System was established in 1785 to provide for the survey of new lands acquired by the U.S. government (Napton and Greathouse 1997). Their system divided territory into a series of townships measuring six miles on each side, with each township divided into 36 sections. Permanent datums, also called monuments, were established at the corners of the townships and frequently at the corners of sections, so there was a permanent reference system for recording land transactions (Napton and Greathouse 1997:189-196).

Although the Arizona territory had fairly much assumed its final form with the 1853 annexation of the Gadsden Purchase from Mexico (for \$10 million), it was not until the Civil War ended in 1865 that the U.S. government began to take a serious interest in the settling of their new territories. After a military base was established at Camp McDowell near the Verde and Salt confluence, survey parties began to lay out the necessary baselines, townships, and sections.

In 1867, William H. Pierce established a primary datum on Monument Hill overlooking the confluence of the Salt and Gila rivers and began to establish the Salt River baseline eastward across the Salt River valley. He also determined the corners of the townships (each measuring 6 by 6 miles sq) north of the baseline. In 1868, a second survey team led by Wilfred F. Ingalls joined the effort to map the corners of the one-square mile sections within each township.

As the survey teams mapped the baselines, township corners, and section corners, they also recorded economically significant items such as water, soil types, and vegetation. These observations were made consistently at each section corner and occasionally at points between section corners, resulting in a vegetation record on a one-mile grid across the entire basin.

(Barbara Brady assisted the authors in this study by reading the survey logs on microfilm fiches curated in the Bureau of Land Management archives in Phoenix, and compiling the data into a series of electronic spreadsheets. Jacobs used her tabulation and written summaries of the data to construct the map in Figure 1.)

The survey notes name nine plant types: palo verde, mesquite, cottonwood, willow, ironwood, greasewood (an early term for creosote), sage (saltbush), cactus, arrowweed. (There is also a single mention to arrowroot).

The survey overemphasized trees, which were considered economically important and woefully underdifferentiated cacti, which were not seen as economically useful (although economically important to Native American groups). Categories of timber,

especially mesquite, are frequently described as timber or brush, and stands of mesquite are variously characterized as “dense” or “a scattering.” The areas described as “dense mesquite” refer to bosques or woodlands of large, full-grown trees. On the other hand, the notes make no attempt to differentiate among types of cactus, despite marked differences in appearance between the tall saguaro and other low-lying types such as cholla and prickly pear. The survey notes fail to mention the presence of saguaro cactus in areas that other contemporary travelers clearly list as present and dense.

The survey notes frequently mention several plant categories in the same location. Rather than mapping all the various permutations, we used the notes to assign each location to a particular plant series in the modern hierarchical system for classifying North American vegetation (Brown et al. 1979; Turner and Brown 1982). The digitized classification code for each series is given in the map key and in Table 1. The Phoenix Basin is located in the Sonoran Desertscrub biome and includes three plant series of the Lower Colorado River Valley and the Arizona Upland Subdivisions (Turner and Brown 1982) and two of the Sonoran Riparian community (Minckley and Brown 1982). The relationship between the plant terms used in the survey notes and these five plant series is also given in Table 1. Two of the series, the saltbush and the creosote-bursage frequently overlap across broad areas, and are shown using three map units.

PLANT COMMUNITIES

The categories of trees that Ingalls (1868) mentioned are associated with three different plant communities: palo verde-saguaro, desert saltbush, and deciduous riparian forest (Table 1). The palo verde tree is one of the dominant trees in the palo verde-saguaro community and is absent in the other plant communities. Cottonwood and mesquite occur in subdivisions of the deciduous riparian forest, and mesquite (usually in brush size) is subdominant in the desert saltbush community. When Ingalls or Pierce described scattered mesquite (or mesquite brush) co-occurring with saltbush, the location was assigned to the saltbush series. Areas described as having mesquite timber (or dense mesquite) were classified as mesquite bosques. Cottonwood and cottonwood with willow represent two separate subdivisions of the deciduous riparian forest community. The vegetation map, however, does not distinguish between these two.

Ingalls mentioned arrowweed only seven times, which was always located along the river and usually co-occurred with cottonwood. As Kwiatkowski (1994:9) noted, “greasewood” is a common synonym for creosote bush and sage for saltbush, which allows a clear and easy discrimination between the creosote bush and desert saltbush communities. The ecotone between these two series is frequently gradual. (Turner and Brown 1982:197); indeed, the majority of the comments include creosote with saltbush. The vegetation map has a unit representing areas in which both communities co-occur.

Ambiguity also arises from Ingall’s use of the general term cactus, which can refer to a very broad class of succulent plants. Approximately half of the mentions of cactus co-occur with palo verde, with the remaining mentions associated with “creosote.” Locations on bajadas and mountain slopes above the creosote bush community are the setting of the palo

verde-saguaro community. Consequently, Ingalls' cactus is encoded in Figure 1 as representing a member of the palo verde-saguaro community.

Several vegetation terms used by Ingalls appeared five or less times. These included ironwood and arrowroot. Ironwood and creosote are subdominant in the palo verde-saguaro community. The descriptive term arrowroot occurred once as a vegetation term along the Salt River in a riparian setting, but its single mention relegated it to a minor value in reconstructing the vegetation picture.

One last note regarding the representativeness of the vegetation terms used by Ingalls. Because surveyors intentionally recorded all timber resources, they overemphasized trees such as mesquite. In documenting the slightest presence of timber for use as fuel or construction materials, they recorded all trees and distinguished their types. This action contrasts with the "lump-all" category of cactus, which probably under-represents this resource. Although cacti may have been valuable to the Hohokam and currently are valuable to populations of O'odham, they clearly were not of use to the Anglo surveyors. Fortunately the consistent references to palo verde or ironwood enabled us to identify the palo verde-saguaro plant community, which contains saguaro and cacti. Ingalls recorded "greasewood brush" and "mesquite" for the area of Papago Buttes that later became Papago Saguaro National Monument (now Papago Peak), but failed to mention any cacti (Kwiatkowski 1988:46), although Cushing described the area in 1887 as a "forest of cacti and palo verde" (Wilcox 1993:60; also Kwiatkowski 1994:9).

A general correlation exists between vegetation and landform. The saltbush series is found on gently sloping lands and valley floors (Turner and Brown 1982:194) and tends to border riparian zones on the valley floor (Figure 1). Mesquite brush can be a common subdominant in the saltbush series. The ecotone between the saltbush community and the creosote bush community typically lies along the transition between the gently sloping valley floor and the bajada (Turner and Brown 1982:201-202). In the creosote bush series, creosote bush is the sole dominant on loamy soils, although its importance is reduced as sand content increases (Turner and Brown 1982:194). It is found on valley floors and bajadas, and its distribution can continue into the mountains from the upper most bajadas (Turner and Brown 1982:193). On the vegetation map, the creosote community extends further away from the riparian zone than the saltbush series.

The palo verde-saguaro community (Table 1) is located mostly on the bajadas and mountain slopes above the creosote bush community. Ingalls noted ironwood with the palo verde-saguaro community only in T2N R5E, which is consistent with Turner and Brown's observation (1982:201) that ironwood is frost sensitive and not found on the lower slopes adjacent to cold valley floors or on northern slopes that support palo verde. Palo verde is noted in more locations by Ingalls and always in areas consistent with where the palo verde-saguaro community should topographically be located, including slopes, broken ground, and multidissected sloping plains (Turner and Brown 1982:200). Ingalls' use of the term cactus was generally consistent with these locations, although several times cactus was mentioned without palo verde in locations designated as "rough ground" or "high ground" along the Salt

River. In such areas, the cacti may have been prickly pear, cholla, or a species other than saguaro.

The notes failed to mention the presence of cacti in significant areas, such as Papago Park, although we know from other sources that Saguaro cacti occurred in abundance there (Kwiatkowski 1988:46). This City of Tempe municipal park was once the Papago Saguaro National Monument (January 1914–April 1930), and its 1900 comprised an extensive saguaro forest (City Planning Commission 1956). Recently, Schroeder conducted an archaeological survey of the area and found few healthy saguaro, pockets of unhealthy saguaro, and almost no cholla (1996:6). This status is in striking contrast with the area when it was a national monument 70 years earlier and with Cushing’s 1887 description of the area as dominated by cholla and saguaro cacti. The vegetation map shows this area as palo verde–saguaro based on these descriptions in historic documents other than the survey logs.

The correspondence in some areas of mesquite bosques and prehistoric irrigation canal headgates and canals running parallel and close to the river channel is particularly interesting. This occurrence strongly suggests the abandoned prehistoric irrigation canals continued to collect and convey water, creating appropriate settings for deciduous riparian forests, such as mesquite bosques. The mesquite bosques in these locations would have been absent when the Hohokam began building irrigation canals in A.D. 300 to 500. The presence of such linear bosques in 1850 represented a persistent legacy of the Hohokam.

Ingalls (1868) and others (Turney 1929) noted a large mesquite bosque on the northern side of the Salt River near the confluence of Cave Creek Wash. Ingalls began the eastern boundary at the headgates of Canal System Six and extended it northward for over three miles across Canal System Four and Five and into portions of Canal System Two. The bosque’s western boundary is not as well defined as the eastern. Ingalls listed patches of dense mesquite as far as 10 miles west of the eastern boundary, but these were interspersed with “scatterings of mesquite,” starting about 5 miles west of the eastern boundary. In addition, Ingalls noted the presence of saltbush with the mesquite, indicating the saltbush community was interfingering with the mesquite bosque.

The areal distribution of this huge mesquite bosque very likely reflects the high water table near the confluence of Cave Creek Wash and the Salt River (Cable and Mitchell 1988). The general soils map of Maricopa County (U.S. Soil Conservation Service 1973) shows an area of old alluvium (Mohall-Contine Association) surrounded by recent alluvium (Gilman-Estrella-Avondale Association) on the valley floor in this area north of the Salt River. The large mesquite bosque is restricted to loamy soils on the recent alluvium (Gilman-Estrella Avondale Association), and the saltbush series to the clay loam soils of the old alluvium (Mohall-Contine Association). The finger of recent alluvium between the old alluvium and the north channel of the Salt River supported “mesquite brush” (Ingalls 1868). A large bosque also apparently existed in this area around A.D. 300 to 500 when the Hohokam first established irrigation canals. It would have hindered the construction of the prehistoric irrigation systems, especially in the eastern end of the mesquite bosque. The western portion of the bosque was more variable. Cable and Mitchell (1988:430, Figure 11.8) have mapped it

more uniformly across the area, but their description does not distinguish between Ingalls' description of dense and scattered mesquite.

Similar combinations of high water table and good soil conducive to mesquite bosques exist in other areas around the Salt River valley, but none were of this magnitude. A small bosque exists near Indian Bend Wash on the north side of the Salt River in T1N R4E. In addition, similar situations exist south of the Salt River along the southern edge of T1N R4E in Canal System One, northwest of the village Los Muertos.

HOHOKAM USE AND TRANSFORMATION OF THE LANDSCAPE OF CANAL SYSTEM TWO

Excavations along Canal System Two illustrate the scale at which the Hohokam were capable of altering their landscape. Clearly the irrigation canals, laterals, and reservoirs themselves were an important part of that transformation; the Hohokam created a built landscape on a scale far larger than nearly any other prehistoric Southwestern society. The effect of the built landscape was also long-lasting. Some 400 years after the Hohokam had left, surveyors working on the cardastal survey saw unnatural lines of mesquite trees snaking across the landscape, following the alignments of abandoned canals that collected enough water to support the denser vegetation.

In the period from A.D. 400 to 1400 the Hohokam of Canal System Two altered their landscape in other ways as well. Centuries of clearing land for agricultural fields, gathering wild foods, and chopping down trees for construction materials and fuel greatly altered the composition of the local vegetation communities. Although these examples are for one particular canal system, similar kinds of changes likely occurred along other Hohokam canal systems.

The focus of the Hohokam subsistence economy was consistently and intensively agriculture: maize, beans, squash, cotton, and tobacco. Maize in particular is found in relatively high and consistent ubiquity in flotation and pollen samples from across the Hohokam region, in settlements both on and beyond the limits of the irrigation systems (Gasser and Kwiatkowski 1991). Some intraregional variation occurred in the preference for other crops; beans, for instance, appeared most frequently at sites in the Tucson Basin and cotton had the highest ubiquity at sites along the Gila River (Gasser and Kwiatkowski 1991:430). The Hohokam also used a variety of weedy annuals, such as different kinds of chenopodea, amaranths, grasses and tansy mustard, that may have been encouraged to grow in the disturbed soils of their fields, but would at any rate certainly have appeared as volunteers around the margins of fields and along the banks of canals (Fish 1984). The Hohokam probably were able to store several years of food in agricultural output alone.

Despite the agricultural productivity in the irrigated areas, the Hohokam also collected a number of highly productive and nutritious wild foods. Such foods were not resorted to as "famine foods" to be used only during periods of low agricultural output;

the wild foods used by the Hohokam were of high nutritional value (many were important sources of minerals and vitamins) and were desirable sources of sugar, complex carbohydrates, and plant proteins. Chief among these were agave, mesquite beans, cactus fruits, cactus buds, and a New World version of barley (Gasser and Kwiatkowski 1991).

Archaeological research at multiple sites on Canal System Two has documented important spatial and temporal variation in strategies for incorporating wild foods into the agricultural subsistence system. The most interesting sets of patterns have to do with the use of mesquite beans, saguaro cactus fruits, and agave (Calbe and Mitchell 1988; Mitchel 1988), as described below.

Population growth on Canal System Two eventually impacted two major features of the natural environment. The large bosque (woodland) of mesquite trees at the confluence of Cave Creek Wash and the Salt was gradually cleared to make way for agricultural fields, and natural stands of saguaro in Papago Hills were depleted and replaced by “planted fields” of agave. Although both vegetation communities were actually outside of the irrigated area of Canal System Two, they were used by the populations living in the villages along the canals.

THE MESQUITE BOSQUE AT THE CAVE CREEK WASH/SALT RIVER CONFLUENCE

In the late 19th century, the mesquite bosque near the mouth of Cave Creek Wash covered nearly 25 square miles (Figure 1). On the western side the bosque inter-fingered with patches of creosote and saltbush communities; mesquite also occurred in these two series as a subdominant species although the plants were smaller and grouped in lower densities than in the true bosque.

Mesquite trees produce a bean pod that can be ground into flour and consumed in a variety of ways and is a good source of carbohydrates and proteins (Castetter and Bell 1942; Gasser and Kwiatkowski 1991). The trees grow large in areas of high groundwater and would have been found bordering the Salt River and near confluences of streams (Mitchell 1989:134). The bosque surrounding the confluence of Cave Creek Wash and the Salt was fed by occasional water flow in Cave Creek and presumably by a large aquifer lying close to the surface replenished by the flow in the wash. Although less desirable than maize, mesquite could be collected and stored in large quantities and used as a diet mainstay; in early historic times, some Yuma groups living along the lower Colorado River used mesquite more than corn because unpredictable river flow made it difficult to raise large quantities of cultigens (Stone 1981).

The large mesquite bosque on the northern side of the Salt was a source of food, construction material, and fuel, but it also was an impediment to agriculture. Initially, mesquite may have been used as an important resource in conjunction with agricultural products. Some of the earliest evidence for the prehistoric occupation of the Salt River comes from the area on the floodplain at the eastern boundary of the bosque, where Early

Ceramic Horizon sites dating to A.D.1 have been found (Cable and Doyel 1985; Cable and Mitchell 1988:424). These early populations lived in dispersed, family-sized settlements on the floodplain of the Salt, growing fields of maize but also harvesting a lot of mesquite beans. By the Pioneer period, some 500 years later, residential villages had been moved to the higher terraces and only field houses were constructed on the floodplain; the field houses were small and presumably were occupied by only a few people during the growing season (Cable and Mitchell 1988:424).

The productivity of a mesquite bosque is not as great per unit area as an irrigated agricultural field, but is nonetheless impressive. The calorie requirements of a single person can be satisfied for a year by mesquite beans harvested from in 1.1 ha (2.2 acres) to 2.4 ha (5.9 acres) of a mature bosque; the comparable figure for an field of maize is 0.3 ha (0.7 acres) to 0.7 ha (1.7 acres) (Kwiatkowski 1994). This calculation of the supporting capability of mesquite is very conservative and assumes that processing of the bean pod recovers only 30% of the available calories per unit weight, the remainder being discarded as chaff or un-ground beans and that fully 50% of the pods are lost to other predators. That is, even consuming only 15% of the yield of each tree, this single 6,480 hectare (16,000-acre) bosque on the Salt River could have supported between 2700 and 5900 people, a population level probably not reached until well into the Colonial period of the Hohokam tradition. Clearly no population would want to subsist solely on mesquite, but this calculation shows that a sizable non-agricultural population could have relied on this bosque as a main resource. While it is certainly the case that a larger population could be supported by using the area for agricultural fields than retaining it as a mesquite bosque, the productivity of mesquite made it a good supplement to agricultural resources.

The calculations of the amount of agricultural land vs. mesquite bosque needed to provide the annual calorie requirements of an individual are based on the data and discussion provided by Kwiatkowski (1994:16-19). An average mesquite tree produces 8.4 kgs of mequite pods per year, but 50% of these are lost to pests and only 30% of the harvested beans are processed into flour; thus an average mature tree produces 1.3 kgs of mesquite flour per year. A kg of mesquite flour provides 2320 calories, which falls between 2000 and 2500 calories needed to support a person per day. An annual requirement of 365 kgs of mesquite flour would require harvesting 281 mature mesquite trees. Since a mesquite bosque averages between 119 (minimum estimate) and 256 (average estimate) trees per hectare, the annual calorie requirements of a single individual could be provided by 2.4 to 1.1 hectares of mesquite bosque. The calculation for agricultural productivity is based on reports that the average Akimel O'Odham (Pima) family of 5 needed between 2 and 5 acres of agricultural land, or between 0.4 ac and 1 ac per person. The irrigated agricultural fields of the Pima provided 50% of 60% of the annual food needs of the Pima; thus between .7 acres (.3 ha) and 1.7 acres (.7 ha) of irrigated agricultural land is needed to provide the annual caloric needs of a single person.

Much of Canal System Two was constructed before the mesquite bosque began to be converted into irrigated fields. By the end of the Pioneer period Canal System Two

had been constructed at least as far west as Pueblo Patricio (Cable and Mitchell 1988:429) and as far north as La Ciudad (Henderson 1987). By the Colonial period, the canal system had expanded northward to Casa Buena (Howard 1988) and westward to Las Colinas (Cable and Mitchell 1988). The canal system reached its fullest extent in the Sedentary and Classic periods (this reconstruction is slightly modified from Cable and Mitchell 1988).

It was not until sometime during the Colonial period that the extensive bosque began to give way to irrigated fields, when Canals Four, Five, and Six were cut through the bosque. This extension of the irrigation canals and fields entailed the cutting down of significant portions of the bosque. Unlike the canals of System Two, the headgates for these canals were not located near bedrock masses and during drought years there would not have been water at the headgate locations to divert into the canals. This is possibly why their construction lagged behind that of Canal System Two (Cable and Mitchell 1988).

The flotation data from Pueblo Patricio (Gasser 1984; Cable and Mitchell 1988:431-432) shows that the mesquite bosque began to make way for irrigated fields towards the end of the Colonial period. Sedentary period field houses contain markedly lower proportions of mesquite relative to corn (Gasser 1984) than Colonial period field houses, indicating that many mesquite trees were cut down for architectural uses or to make way for agricultural fields (Mitchell and Cable 1988:432). In the Sedentary and Classic periods, therefore, the bosque was considerably smaller than it had been at the time of the Early Ceramic Horizon and Pioneer period. It would not regain its initial size until sometime after A.D. 1450 when the Hohokam abandoned Canal System Two.

Even following its reduction in size, the mesquite bosque continued to be exploited by settlements on Canal System Two. Several researchers (Cable and Mitchell 1988; Gasser 1984:193; Mitchell 1989:134-136) have noted that the ubiquity of mesquite in flotation samples declined inversely with distance from the mesquite bosque, even in the Sedentary and Classic periods. Mesquite was found in 54% of the flotation samples from Sedentary and Classic period components of Las Colinas, immediately north of the bosque. Ubiquity values for comparably late sites dropped to 27% at four kilometers and to 19% at six kilometers from the bosque. Almost no mesquite was found at a Colonial period settlement eight kilometers away (Mitchell 1989:136, Table 3), even though the bosque would have been relatively large at that time.

HARVEST OF SAGUARO FRUIT IN THE PAPAGO PARK AND PHOENIX MOUNTAIN AREAS

A variety of cacti also provided foods of high nutritional value. The fruit of the saguaro cactus (*Carnegiea giganteus*) is high in sugar content and calories; it can be dried and stored for winter or boiled fresh in water and allowed to ferment over several days to form a wine. The seeds, separated from the pulp, can be toasted or ground into a meal. The harvesting of saguaro fruit in late June or early July was an important event for the Akimel and Tohono O'Odham, with most other subsistence activities suspended for the

two-week harvest period (Russell 1975). The fruits of other cacti such as prickly pear (*Opuntia*) and hedgehog cactus (*Echinocereus*) were also harvested and eaten. In addition, the roasted buds of the cholla cactus (*Cylindropuntia*) were a good source of calcium (Gasser and Kwiatkowski 1991).

The saguaro cactus is a dominant species in the palo verde-saguaro series located on piedmonts of the local ranges and is seldom found as a subdominant species in other series. Other cacti such as prickly pear and cholla occur on the piedmont but can have a more general distribution.

In the 19th century, the Papago Buttes had thick “forests” of saguaro cacti and palo verde trees, and the larger Phoenix mountain range still supports healthy stands, despite the encroachment of modern development. South of the Salt River, the South Mountain range is an equally large area of the palo verde-cacti association.

The populations of Canal System Two would have collected cactus fruits from the piedmonts of the Phoenix mountain range and Papago Buttes but, for reasons discussed shortly, it is likely that the Papago Buttes did not persist beyond the early part of the Hohokam occupation as a source of cacti fruits. The flotation and pollen data show that Hohokam settlements on the outer edges of the canal system made greater use of cactus fruit than settlements within the irrigation system. Mitchell (1989:136) reported that 19% and 17% of the samples from the Grand Canal Ruin and La Lomita Pequena respectively contained cacti; both settlements were on the outmost canal of System Two. This figure drops to 8% at Casa Buena and 6% at Las Colinas, two settlements further away from the piedmonts.

Although saguaro fruit is a nutritionally valuable food, ripens even in relatively dry years, and can be stored, the harvest period of two weeks ultimately limits the amount of the fruit that can be harvested. Unlike agave, discussed below, the plant grows too slowly for intentional planting in orchard-like quantities. Ethnographic accounts of saguaro-fruit gathering among the O’Odham show that a family of five can harvest and process fruits from approximately 270 plants, or roughly 8000 fruits, in a two-week period (Kwiatkowski 1994).

Given these harvesting rates, it is apparent that the palo verde-saguaro communities in the Papago Buttes area were not large enough to sustain a major harvesting operation by the populations living around the Buttes. Kwiatkowski provided data on the density of cacti in different locations: dense stands of saguaro cacti contain about 48 plants per hectare, and light density stands about 15 plants per hectare. The Papago Buttes area is about 670 hectares in size. Under very good conditions the buttes would have contained enough cacti for the harvesting needs of about 700 people. If the density of plants fell towards the low end of the range, however, only 170 people could have harvested fruits in the area. Because several thousand people lived in Pueblo Grande (west of Papago Buttes) and perhaps something approaching one thousand lived at Plaza Tempe (on the southern bank of the river opposite Papago Buttes), the area was too small to be used effectively for the harvest of cactus fruits.

There is an additional complicating factor. The current population of saguaro in the Papago Buttes area is significantly smaller than in the late 19th century or early 20th century (Kwiatkowski 1988:42; Estabrook 1981). Cacti are susceptible to damage through trampling and heavy foot traffic, and population densities in the cities of Tempe and Phoenix have degraded the cactus communities in the Papago Buttes area.

This impact may have occurred in prehistoric times as well, especially since the populations of Plaza Tempe and Pueblo Grande would have used the Papago Buttes to gather firewood and hunt rabbits. Thus, the Papago Buttes were too small and probably too close to the irrigated Hohokam fields to have been a sustainable source of cactus fruit. It is likely that the palo verde-saguaro community along the southern margin of Phoenix mountain and Camelback mountains underwent similar degradation, but in these areas the association was much larger and the more northern sections probably remained viable zones for the harvesting of fruit throughout the occupation of Canal System Two.

TRANSPLANTING AGAVE TO THE AREA OF CANAL SYSTEM TWO

Agave played an unusual role in the Hohokam economy. The plant was not domesticated, in that human use had not selected for genetic modifications of the plant that would increase its yield under cultivation (Rindos 1980), but it was nonetheless intentionally planted and tended in settings much lower in elevation than its natural range (Gasser and Kwiatkowski 1991; Fish et al. 1992). The long time to maturation of the edible stalk (about seven years) and the ability of agave to replicate through cloning provided little opportunity for domestication; there was little variation among generations, and generations were of such long intervals that human use of the plant did not have much impact in selecting for genetic modifications.

Nonetheless, the Hohokam intentionally planted agave both on rocky piedmonts at the base of local mountains (e.g. Fish et al. 1992) and around the margins of irrigated fields on the canal systems (Gasser and Kwiatkowski 1991; Mitchell 1989). On the piedmonts, plants were encouraged to grow by placing them at the center of small rock piles that served to retain the minute amounts of moisture received from rain (Fish et al. 1992). Within the study area, agave was planted on artificial terraces constructed in the Papago Butte area (Kwiatkowski 1988) and on the steep, north-facing slope of Tempe Butte (Kwiatkowski 1999). It may have been planted more broadly in the area of the Buttes as well. Planted areas of agave may have replaced the declining saguaro cacti in the Papago Buttes. It is also clear, however, that agave was grown among irrigated fields across large parts of Canal System Two. It was unlike mesquite and cacti, the use of which declined with distance from the largest natural stands of the vegetation type. The ubiquity of agave does not drop off with distance from the piedmonts of Papago Buttes and Phoenix mountains (Cable and Mitchell 1988:441-442; Mitchell 1989). We do not know the manner in which agave was grown on the margins of irrigated fields, but apparently it was grown in many parts of Canal System Two even though it did not require irrigation. Agave cultivation appears to have provided an alternative to more extensive use of water-intensive crops such as corn (Gasser and Kwiatkowski 1991:426).

CONCLUSION

The Hohokam use of irrigation agriculture enabled thousands of peoples to live in relatively circumscribed areas for centuries at a time; System Two, for instance, existed from at least as early as A.D. 700 (Henderson et al. 1987:83-84; Cable and Doyel 1986) to about A.D. 1450 (Howard 1988; Mitchell 1989a), a period of 750 years. Such concentrations of people living for long periods of time along the irrigation canals led to changes in the natural vegetation of surrounding areas.

The Hohokam altered the vegetation communities of their landscape through three sorts of processes. In some situations they intentionally removed vegetation, as when they cut down forests of mesquite trees to make room for agricultural fields. In other instances some types of plants declined in numbers unintentionally as a consequence of people living in the same place for a long period of time; the heavy foot traffic of people moving about the landscape, for instance, reduced and possibly eliminated stands of the saguaro cactus in the Papago Buttes area. And in the third process the Hohokam intentionally transplanted natural vegetation into the areas next to their villages; the example for Canal System Two is that of agave plants that were transferred from natural stands at higher elevations to the Papago Buttes area and among the irrigated fields of Canal System Two.

The reduction in the size of the mesquite bosque occurred primarily after the shift from floodwater farming to irrigation farming. Irrigation canals were extended into areas that previously supported a riparian deciduous forest. Much of this wild resource, valuable as both food and as a source of timber, was replaced by irrigated fields of corn, beans, squash, cotton, and possibly tobacco.

The people living on the canals also impacted the palo verde-saguaro plant community in the Papago Buttes area and along the southern edge of the Phoenix Mountains. The fruit of the saguaro cactus was a highly valued food, and a wine produced from the fruit may have been used on ceremonial occasions. However, the plants do not survive well in areas of heavy foot traffic, and it is likely that stands of saguaro adjacent to the agricultural fields of Canal System Two gradually diminished in size as people from the local villages combed the area to gather firewood, collect natural plant foods, and hunt small game. With time the Hohokam of Canal System Two would have had to venture further from their villages to continue their harvest of Saguaro fruits.

As the stands of saguaro cacti in the Papago Buttes area declined in abundance, they were replaced by planted fields of agave. Agave was not a domesticate, but the Hohokam transplanted immature plants from natural stands at higher elevations to terraces and rock-pile fields next to their agricultural fields on the valley floor. Agave was introduced into the Papago Buttes area because it could be grown on poor soils and required little water, but it was important enough as a resource that Agave was also grown along the edges of canal-irrigated fields within Canal System Two, well outside of its natural range. The Hohokam

tended to baked agave in large batches in earthen ovens, which suggests they served it when there were large gatherings of people assembled for feasts or ceremonies.

This is only one case of one Hohokam canal system, but it suggests the scale at which the Hohokam modified their landscape, especially in the regions where they built irrigation networks. The case also illustrate the extent to which high-calorie and highly-productive wild foods continued to remain important in the Hohokam subsistence system, not as replacements for agricultural foods but rather as foods served at feasts. The effects of Hohokam irrigation agriculture extended well beyond the edges of the agricultural fields.

REFERENCES

Brown, David E., Editor

- 1982 Biotic Communities of the American Southwest-U.S. and Mexico. In *Desert Plants 4 (1-4)*. The University of Arizona for the Boyce Thompson Southwestern Arboretum, Superior.

Brown, David E., Charles H. Lowe, and Charles P. Pase

- 1979 A Digitized Classification System For The Biotic Communities Of North America, With Community (series) and Association Examples For The Southwest. *Journal of the Arizona-Nevada Academy of Science*, 14(suppl.1):1-16. [Republished 1982 in *Desert Plants, Vol. 4 (1-4)*, edited by David E. Brown . The University of Arizona for the Boyce Thompson Southwestern Arboretum, Superior.

Cable, John S. and David E. Doyel

- 1985 Hohokam Land-use Patterns Along the Terraces of the Lower Salt River Valley: The Central Phoenix Project. In Proceedings of the 1983 Hohokam Symposium, edited by A.E. Dittert, Jr., and D.E. Dove. *Arizona Archaeological Society Occasional Paper 2*. Phoenix.

- 1986 Pioneer Period Village Structure and Settlement Pattern in the Phoenix Basin. In *The Hohokam Village*, edited by David E. Doyel, pp.

Cable, John S. and Douglas R. Mitchell

- 1988 La Lomita Pequena in Regional Perspective. In *Excavations at La Lomita Pequena, a Santa Cruz/Sacaton Phase Hamlet in the Salt River Valley*, edited by Douglas R. Mitchell, pp. 395-446. Soil Systems Publications in Archaeology, Number 10.

Castetter, Edward F., and Willis H. Bell

- 1942 *Pima and Papago Indian Agriculture*. The University of New Mexico Press, Albuquerque.

City Planning Commission (City of Phoenix)

- 1956 Papago Park, A Proposed Plan. Unpublished manuscript on file, Hayden Library, Government Publications Section, Arizona State University. Tempe.

Cushing, Frank Hamilton

- 1887 The Hemmenway Southwestern Archaeological Expedition. Unpublished diary. Ms. on file, Pueblo Grande Museum and Cultural Park, Phoenix, Arizona.

Estabrook, T. H.

- 1981 Vegetation Disturbance in Phoenix South Mountain Park, Arizona. Unpublished M.A. thesis, Department of Geography, Arizona State University, Tempe.

Fish, Suzanne K.

- 1984 Agriculture and Subsistence Implications of the Salt-Gila Pollen Analysis. In *Hohokam Archaeology along the Salt-Gila Aqueduct, Central Arizona Project, Vol. VII: Environment and Subsistence*, edited by Lynn S. Teague and Patricia L. Crown. Arizona State Museum Archaeological Series No. 150. Tucson.

Fish, Suzanne K. and Paul R. Fish, and John H. Madsen (editors)

- 1992 *The Marana Community in the Hohokam World*. Anthropological Papers No. 56, University of Arizona Press, Tucson.

Gasser, Robert E.

- 1984 Analysis of Prehistoric Flotation Samples from the Murphy's Addition. In *City of Phoenix, Archaeology of the Original Town Site: The Murphy's Addition*, edited by John S. Cable, Susan L. Henry, and David E. Doyel. Soil Systems Publications in Archaeology No. 3. Phoenix.

Gasser, Robert E., and Scott M. Kwiatkowski

- 1991 Food for Thought: Recognizing Patterns in Hohokam Subsistence. In *Exploring the Hohokam: Prehistoric Peoples of the American Southwest*, edited by G. J. Gumerman, pp. 417-459. Amerind Foundation New World Series. University of New Mexico Press, Albuquerque.

- 1975 *Hecla II and III, an Interpretative Study of Archaeological Remains from the Lakeshore Project, Papago Reservation, South Central Arizona*. Arizona State University Anthropological Research Paper 9, Tempe.

Henderson, T. Kathleen

- 1987 *Structure and Organization at La Ciudad*. Anthropological Field Studies No. 18. Office of Cultural Resource Management, Arizona State University, Tempe.

Howard, Jerry

- 1988 *Excavations at Casa Buena: Changing Hohokam Land Use Along The Squaw Peak Parkway*. Soil Systems Publications In Archaeology No. 11 (two volumes). Phoenix.

Ingalls, Wilfred F.

- 1868 Gila and Salt River Meridian Survey: Maps of T1N R1E, T1N R2E, T1N R3E, T1N R4E, T1N R5E, T2N R1E, T2N R2E, T1N R3E, T2N R4E, T2N R5E. Microfiche on file, Bureau of Land Management, Phoenix, Arizona.

Kwiatkowski, Scott Michael

- 1988 The Effects of Postoccupational Disturbance on Archaeobotanical Data from AZ U:9:24 (ASU). Unpublished M.A. thesis, Department of Anthropology, Arizona State University, Tempe.

- 1994 Prehistoric Biotic Communities and Ecosystem Dynamics Near Pueblo Grande. In *The Pueblo Grande Project: Environment and Subsistence, Volume 5*, edited by Scott Kwiatkowski, pp. 5-34. Soil Systems Publications in Archaeology, Number 20, Volume 5.

Kwiatkowski, Scott M.

- 1999 The Rio Salado Parkway Realignment Project: Prehistoric and Historic Archaeological Investigations at the Foot of Tempe Butte, Tempe, Maricopa County, Arizona. Archaeological Research Services Project Report No. 98:10.

Minckley, W.L. and David E. Brown

- 1982 Wetlands. In *Desert Plants*, Volume 4., Numbers 1-4. Edited by David E. Brown, The University of Arizona Press, Tucson.

Mitchell, Douglas R.

- 1988 La Lomita Pequena: relationships between plant resource variability and settlement patterns in the Phoenix Basin. *Kiva* 54(2):127-146.

- 1989a *Archaeological Investigations at the Grand Canal Ruins: A Classic Period Site in Phoenix, Arizona*. Soil Systems Publications in Archaeology No. 12. Phoenix

- 1989b *El Caserio: Colonial Period Settlement along the East Papago Freeway*. Soil Systems Publications in Archaeology No. 14. Phoenix.

Napton, L. Kyle and Elizabeth Anne Greathouse

- 1997 Archaeological Mapping, Site Grids, and Surveying, Chapter 9 in *Field Methods in Archaeology* edited by Thomas R. Hester, Harry J. Shafer, and Kenneth L. Feder. Mayfield Publishing Company, Mountain View, CA.

Pierce, William H.

- 1867a Baseline Survey. Microfiche on file, Bureau of Land Management, Phoenix, Arizona.

Pierce, William H.

- 1867b Meridian Survey. Microfiche on file, Bureau of Land Management, Phoenix, Arizona.

Rindos, David

- 1980 Symbiosis, Instability and the Origins and Spread of Agriculture, A New Model. In *Current Anthropology* 21: 751-772. [Reprinted 1996 in *Evolutionary Archaeology: Theory and Application*, edited by Michael O'Brien, pp. 209-235. University of Utah Press, Salt Lake City].

Russell, Frank

1975 *The Pima Indians*. Twenty-Sixth Annual Report of the Bureau of American Ethnology, 1904-1905. Reprinted. University of Arizona Press, Tucson. Originally published in 1908, Smithsonian Institution, Washington D.C.

Schroeder, K. J., with a contribution by Todd Bostwick

1996 *Archaeological Survey of Phoenix's Papago Park, Maricopa County, Arizona*. Parks, Recreation and Library Department, City of Phoenix.

Stone, Connie L.

1981 Economy and Warfare along the Lower Colorado River. *Anthropological Research Papers* 24:183-197. Arizona State University, Tempe.

Turner, Raymond M., and David E. Brown

1982 Sonoran Desertscrub. *Desert Plants* 4(1-4):181-221. Edited by David E. Brown, University of Arizona Press, Tucson.

Turney, Omar

1929 Prehistoric Irrigation. *Arizona Historical Review* 2(5). Phoenix, Arizona.

U.S. Soil Conservation Service

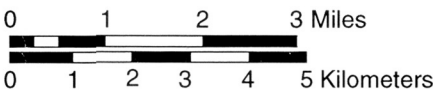
1973 General Soil Map of Maricopa County and Gila River Indian Reservation, Arizona.

Wilcox, David R.

1993 The Evolution of the Chaco Polity. In *The Chimney Rock Archaeological Symposium*, edited by J. McKim Malville and Gary Matlock, p 60. Rocky Mountain Forest and Ranger Experiment Station. USDA Forest Service, General Technical Report RM-227. U.S. Department of Agriculture, Fort Collins, Colorado.

Vegetation of Phoenix, 1867 - 1868

(Based on Public Lands Survey logs)



- Labels for the Vegetation Series**
- C Cotton - Willow series (224.53)
 - M Mesquite series (224.52)
 - Sb Desert Saltbush series (154.17)
 - Cr Creosotebush - Bursage series (154.11)
 - Cr/Sb Creosotebush / Saltbush mixed
 - Pv/S Paloverde - Mixed Cacti series (154.12)

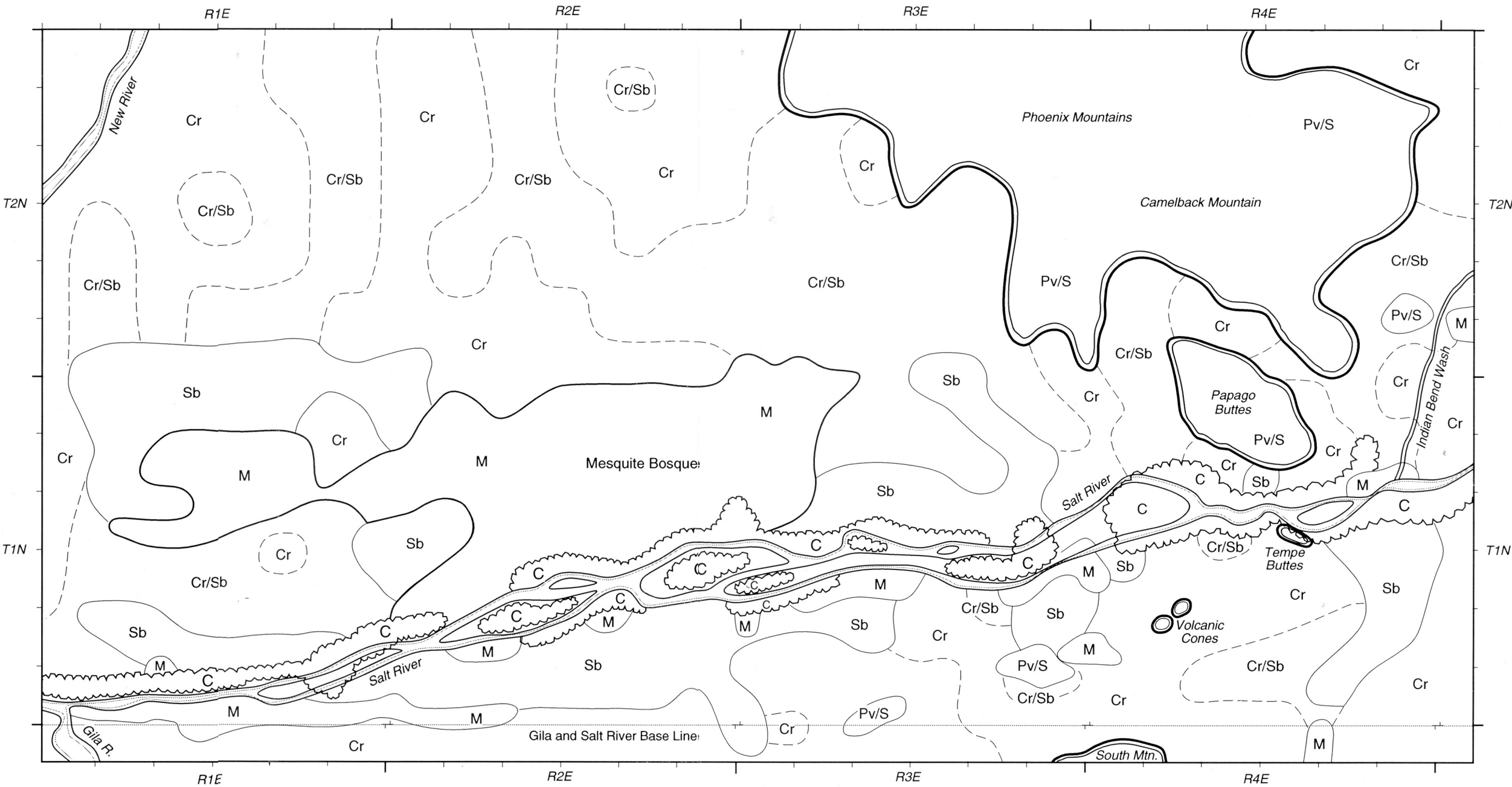


Table 1. The Relationship of Plant Categories Employed on the Cadastral Survey to the Modern Classification of North American Biomes (Brown et al. 1979).

PLANT CATEGORIES USED IN 1860s BY STAFF OF THE CADASTRAL SURVEY	PLANT SERIES (TURNER AND BROWN 1982)				
	Paloverde- Cactus (154.12)	Creosote Bursage (154.11)	Desert Saltbush (154.17)	Riparian Mesquite (224.52)	Riparian Cottonwood- Willow (224.53)
Paloverde	XX				
Cactus	XX	x			
Ironwood	x				
Creosote ("greasewood")	x	XX			
Saltbush ("sage")	x		XX		
Scattered Mesquite			x	x	
Dense Mesquite				XX	
Cottonwood					XX
Willow					XX
Arrowweed					x
Arrowroot					x

XX - The prominent plants in the series

x - Subdominant plants in the series